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GARNETS

(GEM STONES)

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GARNETS (GEM STONES) [1]

By I. Aitkens [2]

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INTRODUCTION

Garnets, although very attractive stones, are so abundant that they are not highly valued. To escape the sales resistance that their lack of rarity engenders, garnets are often marketed under such suggestive names as "Cape ruby," "Uralian emerald," "South African jade," and similar terms.

DESCRIPTION AND PROPERTIES

Garnets are a closely related group of silicate minerals, which crystallize in the same forms and have similar physical properties. Although their compositions vary widely, they are all orthosilicates having the same general formula.

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[1] The Bureau of Mines will welcome reprinting of this article, provided the following footnote acknowledgment is used: "Reprinted from U. S. Bureau of Mines Information Circular 6518."

[2] Rare metals and nonmetals division, U. S. Bureau of Mines.

The formulas of the principal varieties are as follows:

Grossularite,	lime-alumina garnet,	$Ca_3Al_2(SiO_4)_3$.
Pyrope,	magnesia-alumina garnet,	$Mg_3Al_2(SiO_4)_3$.
Almandite,	iron-alumina garnet,	$Fe_3Al_2(SiO_4)_3$.
Spessartite,	manganese-alumina garnet,	$Mn_3Al_2(SiO_4)_3$.
Andradite,	lime-iron garnet,	$Ca_3Fe_2(SiO_4)_3$.
Uvarovite,	lime-chrome (alumina) garnet,	$Ca_3(Cr,Al)_2(SiO_4)_3$.

Garnets crystallize with cubic symmetry, usually in rhombic dodecahedra or trapezohedra, or in a combination of the two. The hexoctahedron is found in some combinations, but the octahedron is rare. The crystals have an imperfect cleavage or parting parallel to the dodecahedron, which is seldom observed in thin sections of garnet crystals.

The hardness of the different varieties ranges from 6.5 to 7.5 (on Moh's scale), the lime-alumina garnet being the softest. Generally, sound crystallized garnet has a hardness of 7.5, which is slightly greater than that of quartz (7.0). The specific gravity ranges from 3.4 to 4.3, according to the composition, while the refractive power is fairly high also varying with the composition. Garnet is isotropic and the index of refraction ranges from 1.705 to 1.895.

The specific gravity and index of refraction of each of the several varieties are as follows:

Specific gravity and index of refraction of varieties of garnets

Variety	Specific gravity	Index of refraction
Grossularite (lime-aluminum)	3.4-3.7	1.735
Pyrope (magnesium-aluminum)	3.7-3.8	1.705
Almandite (iron-aluminum)	3.9-4.2	1.830
Spessartite (manganese-aluminum)	4.0-4.3	1.800
Andradite (calcium-iron)	3.8-3.9	1.895
Uvarovite (calcium-chromium)	3.4-3.5	1.870

The dispersion is likewise high, ranging from 0.024 to 0.028 for most varieties. However, the demantoid or grass-green andradite, has a dispersion of 0.057, which is comparable to that of the diamond, and when the color is not too dark, the stones have considerable brilliancy and fire.

Generally, light-colored garnets are transparent to translucent, while the dark-colored are translucent to opaque. The luster is vitreous to resinous. Garnets may be colorless, red, brown, yellow, green, or even black. In fact, garnets of any color except blue may be observed. While the colors are due mainly to the iron, manganese, or chrome entering into the characteristic formulas, the shade may be greatly modified by the impurities present.

Under the six large classifications, the garnet group of gems is further divided into many classes and divers names have been given them. The following alphabetical list gives the names commonly used for these different varieties:

Names commonly used for the different varieties of garnet

Allochroite:	A brown or reddish brown variety of andradite.
Almandite (almandine):	A columbine-red or deep crimson and violet garnet.
Andradite:	A brownish red, brown, black, yellow, or green variety of garnet.
Aplome:	A dark brown variety of andradite.
Cape ruby:	A blood-red pyrope garnet from South Africa.
Carbuncle:	Clear, deep red almandite.
Cinnamon stone:	A cinnamon-colored variety of grossularite.
Colophonite:	A brownish yellow to reddish brown variety of andradite.
Demantoid:	A grass-green variety of andradite.
Essonite:	A yellow variety of grossularite.
Grossularite:	A pale green or yellow garnet.
Hessonite:	Yellow or cinnamon-colored grossularite.
Hyacinth:	A red zircon; also wrongly applied to essonite or other light-colored garnets.
Jacinth:	A yellow zircon; also improperly applied to essonite and other yellowish garnets.
Jelletite:	A green variety of andradite.
Melanite:	A dull black andradite.
Pyrope:	A blood-red garnet.
Rhodolite:	A rose-colored garnet, between pyrope and almandite, (2 molecules of pyrope and 1 of almandite)
Romanzovite:	A brown grossularite.
Spessartite:	A yellow, brown, or red garnet, (common variety of unpopular shades).
Succinite:	Amber-colored grossularite.
Topazolite:	Colorless, yellowish, or greenish andradite.
Uralian emerald:	Siberian demantoid (green garnet).
Uvarovite:	A green garnet containing chromium.

Localities

Some of the localities where the different varieties of garnet are found are as follows:

Table 1. - Some of the localities where the different varieties of garnet are found

Variety	Localities
Almandite	(Bohemia, Brazil, Ceylon, India, Japan, South Australia, Tyrol, Uruguay, Arizona, Colorado, New Mexico, New York, North Carolina, Pennsylvania; and Fort Wrangell, Alaska.
Andradite	(Finland, Mexico, Norway, Tasmania, Arkansas, and Arizona.
Demantoid	(Hungary, Russia, Saxony, and the Urals.
Topazolite	(Piedmont region of Italy.
Uralian emerald	(Ural Mountains.
Grossularite	(Canada, Ceylon, Mexico, Switzerland, and Colorado.
Essonite	(Ceylon, Mexico, and California.
Pyrope	(Australia, Bohemia, Brazil, Ceylon, Madagascar, Rhodesia, Saxony, South Africa, Arizona, California, Colorado, Kentucky, New Mexico, North Carolina, and Utah.
Rhodolite	(Mason County, N. C.
Spessartite	(Bavaria, Ceylon, India, Tyrol, Colorado, Nevada, New York, Utah, and Virginia.
Uvarovite	(Canada, Russia, South Africa, Tasmania, and at Bisersk in the northern Urals.

USES

Besides being used in jewelry, gem garnet is also utilized for watch jewels and to a limited extent as a jewel in the bearings of meters and scientific apparatus. Ordinary garnet has been used principally as an abrasive. Abrasive garnet is used either in the form of a manufactured paper, like sandpaper, or as a powder for grinding and polishing.

IDENTIFICATION

Garnets are readily recognized by their characteristic isometric crystals, their hardness, color, etc., but it may require a chemical analysis positively to distinguish the different members of the garnet group. The iron garnets, almandite and andradite, fuse readily to magnetic globules. Andradite is somewhat difficult to dissolve even in hydrochloric acid and gelatinizes imperfectly upon evaporation. While other garnets are practically insoluble in acids, all of them except uvarovite, will dissolve in hydrochloric acid after simple fusion and will gelatinize upon evaporation. Uvarovite is a calcium-chromium garnet, and any garnet containing a considerable percentage of chromium is usually infusible; this accounts for the fact that uvarovite is almost infusible.

Pyrope, the typical blood-red common garnet of jewelry may be distinguished from the red almandine by its lower refraction and density. Cinnamon stone, another variety of red garnet is often confused with hyacinth (zircon), but it too may be readily distinguished by its much lower specific gravity.

SUBSTITUTES

There is no commercial advantage in manufacturing artificial garnets. Of all the semiprecious gem stones garnets are the most plentiful and the cheapest. Instead of substituting other minerals for it, different varieties of garnet are sold under names suggestive of the more valuable gems. Thus, red pyrope garnets are sold under trade names such as American ruby, Arizona ruby, California ruby, Cape ruby, Colorado ruby, Montana ruby, and Rocky Mountain ruby. In each case the trade name indicates the locality from which these specific stones come.

HISTORY

The name garnet comes from the Latin word, granatus, meaning seed-like. The garnet crystals when embedded in their pudding-like matrix closely resemble the seeds of a pomegranate and are said to have the shape and color of the seeds of that fruit.

Almandite

Almandine (almandite), or precious garnet, derives its name from alabandicus, the name given by Pliny to a stone found at Alabanda, a town in Asia Minor.

Pyrope

Pyrope, the name of the magnesium-aluminum garnet, is from the Greek, and means fiery-eyed, in allusion to its deep red color.

Grossularite

Grossularite, the lime-alumina garnet, gets its name from the Latin, grossulari, a gooseberry—so called because of the common pale green color of its crystals.

Spessartite

Spessartite, the manganese-aluminum garnet, derives its name from Spessart, Bavaria, where it occurs in red trapezohedra in granite.

Uvarovite

Uvarovite, the calcium-chromium garnet, was named in honor of a Russian minister, Count Uvarov.

Andradite

Andradite, the calcium-iron garnet, is named after d'Andrada, a Portuguese mineralogist who made a study of garnet more than a century ago.

MODE OF OCCURRENCE

Garnet occurs as an accessory constituent of metamorphic and sometimes of igneous rocks. Its most characteristic occurrence is in mica and hornblende schists, and in gneisses. However, frequently it occurs as rounded grains in stream and sea sands. It is found in pegmatite veins and occasionally in granite rocks.

Grossularite is common in limestones and crystalline schists.

Almandite is especially characteristic of mica schists.

Pyrope is found in peridotites and the serpentines derived from them.

Spessartite is found in granitic rocks, in quartzite, in certain schists, and in the igneous rock, rhyolite.

Uvarovite is found in serpentine associated with chromite.

Andradite is a typical metamorphic mineral, but is found also in igneous rocks which have assimilated fragments of limestone.

MINING METHODS

The small amount of gem garnet that is mined annually is obtained from small quarries that are worked irregularly, or it is collected from surface deposits. Generally, in quarries the rock is drilled by hand and shot with small charges of explosives. Black powder is used in preference to dynamite, because its shattering effect is less; after the rock is broken, the garnet crystals may then be removed carefully by hand.

In Alaska, the almandite garnet is mined without explosives. To loosen the garnets embedded in the schists, holes are drilled in the mica schist and filled with quicklime. The lime has a disintegrating effect which serves to split up the soft, dry rock formation and thus separate the garnets from the mass.

DOMESTIC PRODUCTION

The production of gem garnet in the United States has always been exceedingly small. Although the mineral is widely distributed through the States and considerable garnet of gem quality has been collected, the annual output since 1901 has declined. The following table gives the value of gem garnet produced in the United States from 1890 to 1921, when the United States Geological Survey discontinued the canvass of producers:

Table 2. - Value of gem garnet produced in the United States, 1890-1921 1/

Year	Value	Year	Value	Year	Value
1890	$2,308	1901	$22,100	1912	$ 860
1891	3,000	1902	2,500	1913	4,285
1892	5,250	1903	3,000	1914	1,760
1893	2,000	1904	3,000	1915	4,523
1894	4,300	1905	5,000	1916	1,542
1895	2,350	1906	3,000	1917	624
1896	2,600	1907	6,460	1918	1,277
1897	9,000	1908	13,100	1919	1,630
1898	7,000	1909	1,650	1920	331
1899	7,000	1910	3,100	1921	606
1900	21,500	1911	2,065		

1/ Compiled from Mineral Resources of the United States, Pt. II (annual chapters).

DEPOSITS IN THE UNITED STATES AND ALASKA

Arizona and Utah

In the Navajo Reservations of Arizona and Utah, many fine gems of the pyrope variety have been found. The three principal producing localities are Mule Ear and Moses Rock in Utah, and Garnet Ridge in Arizona. Here the crystals are collected from the surface sands and gravels by the Indians and sold to traders and tourists. According to Gregory,3/ this garnet material is exposed by the strong southwest winds that sweep over this district and consequontly the garnets are strewn over the surface or accumulated in pockets and riffles.

California

Fine specimens of hyacinth-colored garnets were recovered from the Hercules mine near Ramona. These consisted of garnet associated with albite feldspar. Hessonite of an excellent quality has also been found in San Diego County, Calif., and both pyrope and almandine have been found to a small extent in several localities in the State.

3/ Gregory, H. E., Garnet deposits on the Navajo Reservation, Arizona and Utah: Econ. Geol., vol. 11, 1916, p. 223.

Colorado

A large quantity of spessartite garnet was obtained from the Ruby Mountain locality, across the Arkansas River from Nathrop, Colo. According to Cross,[4] these garnets occur in cavities in rhyolite associated with topaz and other minerals. In the basin of the North Fork of the Arkansas River, a discovery was made of small bright yellow grossularite garnets. These garnets occur in cavities in altered granitic rock and make good specimens, although they are too small for cutting into gem stones.

Idaho

In various parts of Boise County, Idaho, garnets suitable for cutting into small gems are picked out of the gold placers. In the Deadwood Gulch placers, dark-red garnets as large as pecans have been found which are sufficiently clear and light-colored for cutting into faceted gems.

Garnets have also come from a locality near Orofino, Nez Perce County, Idaho. The stones here suggest spessartite. The pebbles show rounded crystal faces, which is an unusual feature of garnet pebbles.

Massachusetts

In northern Massachusetts, not far from the Vermont line, about 50 deep, rich, red garnets were picked up on the surface of a micaceous schist rock. From these, perfect gems of 2 carats were cut and some larger ones that were slightly flawed; however, apparently no development work has been undertaken.

New Hampshire

A quantity of deep red garnets were discovered on a hill near Chesham, in Cheshire County, N. H. These garnets were small, but clear gems ranging from one-eighth to one-half of a carat were produced.

New York

The pegmatite veins of the gneiss of Manhattan Island, New York City, have yielded some very large garnet crystals. These may be seen in the New York Mineralogical Club collection in the Museum of Natural History.

James G. Manchester found an incomplete crystal, about 3 inches in diameter, of fine gem quality in the Washington Heights section of New York City about October, 1916. It is said that although the New York material is similar to the spessartites of Amelia Court House, Va., it is superior. Manchester and Stanton,[5] describe it as "more brilliant, more perfect, more translucent, and of a more beautiful color, being a clear, slightly orange-red rather than the cloudy brownish red." The crystal found by Manchester was cut into 39 brilliant and step-cut stones of a combined weight of about 19 carats.

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[4] Cross, Whitman, Topaz and garnet in Rhyolite: Am. Jour. Sci., 3d ser., vol. 31, 1886, pp. 432-438.

[5] Manchester, J. G., and Stanton, G. S., A Discovery of Gem Garnet in New York City: Am. Mineral., vol. 2, 1917, pp. 85-86.

North Carolina

Rhodolite is the name given by Hidden and Pratt,[6] to the rose-pink garnet found in Macon County, N. C. Practically the entire production of rhodolite has come from Macon and Jackson Counties, N. C. According to Kunz,[7] large garnets are not plentiful, although stones weighing as much as 14 carats have been cut. It was estimated that about $53,000 worth of these garnets had been sold prior to 1910. For several years this rhodolite was thought to be a variety of almandine, until analysis showed that its composition is equivalent to 2 molecules of pyrope and 1 of almandine. Clear rhodolite garnets are exceptionally free from inclusions, very brilliant, and show a fine display of color, from pale rose-pink to dark rose-pink, and some have a purplish cast.

Pennsylvania

Specimens of rough garnet in mica schist and gems cut from them were obtained from a locality in eastern Pennsylvania. Some of these cut gems had the fine violet red color of almandine.

Alaska

The deposit of almandite garnet which was discovered about 7 1/2 miles from Wrangell, Alaska, was developed by the Alaska Garnet Mining and Manufacturing Co. of Minneapolis, Minn. Here, many of the fine crystals, with their associated mica-schist matrix, are sold for cabinet specimens and are cut into gems from occasional fine material. It is said that although the surface stones are badly flawed, gems of fine color and quality are obtained by deep mining. These garnets are thickly distributed through the mica schists.

THE INDUSTRY IN FOREIGN COUNTRIES

Bohemia is the principal source of gem garnet. In fact, for many years it has been almost the only commercial source of the common ruby garnet found in the jewelers' shops. The fiery red pyrope constitutes the chief supply of Bohemian garnet, and is undoubtedly the most popular variety of semiprecious garnet. The most noted region is about 60 kilometers north of Prague, and it is claimed that this is probably the only place in the world in which the collection and preparation of gem garnet for the market has been of sufficient importance to approach an established industry.[8]

According to Hall,[9] considerable quantities of uvarovite have been found recently in the Bushveld in Western Transvaal, about 40 miles west of

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[6] Hidden, W. E., and Pratt, J. H., Rhodolite, a New Variety of Garnet: Am. Jour. Sci., 4th ser., vol. 5, 1898, pp. 294-296.

[7] Kunz, G. F., History of the Gems Found in North Carolina: Geol. and Econ. Survey No. 12, 1907, pp. 50-51.

[8] Myers, W. M., and Anderson, C. O., Garnet: Its Mining, Milling, and Utilization: Bureau of Mines Bull. 256, 1925, pp. 6-11.

[9] Hall, A. L., Chrome-Garnet from the Western Transvaal Bushveld: South African Min. and Eng. Jour., Sept. 27, 1924, pp. 63-64.

Pretoria. This garnet, which is found intimately associated with chromite, is being marketed under the trade name of South African jade. The range of color is wide, but the deep green variety is the most valuable because of its resemblance to true jade. This particular variety brings a higher price in the Far East than is paid for crude Burmese jade.

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